

# Middle Management of Research

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## MIDDLE MANAGEMENT OF RESEARCH

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### SUMMARY

The role of the middle manager in a research organization is discussed herein. The middle manager serves as a liaison between upper management and researchers to assure that individual research projects manifest the goals of the organization. The author draws on his long experience in this role to describe management practices that have proven successful. The article begins with a general discussion of the makeup of a research environment, derived from a study of a division involved in aerospace research and development (R&D). The study emphasized the importance of planning and management style in producing an attractive environment.

This paper describes management practices, which include goal-setting, planning, staffing, reviewing and evaluating, and rewarding. The importance of selecting and defining an appropriate research area is discussed. The author emphasizes that in relating to the staff the middle manager must cultivate the "human side" of supervision, develop the art of delegating responsibility, judiciously select facilities, and provide recognition and meaningful rewards to develop a productive research staff. The development of the staff is probably the most important and challenging role of the manager.

### INTRODUCTION

Managing basic or applied research is a distinctively different operation requiring unique management skills and approaches. It differs significantly from the management style of task- or product-oriented organizations where the output is both visible and quantifiable. It is true that research results are chronicled in reports or briefs, but the eventual application of research results may take a decade or more to reach the product line where their tangible benefits are obvious. Within the broad category of research, I imagine there are also differences in how a particular research is managed or should be managed, and these differences could be as diverse as the type of research itself. In this paper, I don't intend to address the diversity of research management methods or styles associated with broad categories of research. I'm just not confident to take on that assignment. Instead, I will rely on my own experience in middle management of research in the aerospace arena and share some observations. I make no pretense of knowing all the answers; nor have I been an ideal manager who always did the right thing. What follows in this paper is some commentary on management methodology which I feel has been successful. A long career as a research manager has given me the advantage of the perspective of time in selecting comments pertaining to research management. Hopefully, these comments will help a younger person embarking on a management career in research.

## RESEARCH ENVIRONMENT

In 1982 I was involved in an evaluation of the research environment in a major technical division (personal communication with Dr. Larry A. Diehl and Gregory M. Reck of NASA) of a research laboratory. The objective of the study was to identify the most important issues and practices in managing the research operation in this division. The division comprised several branches which conducted research relevant to the airbreathing jet engine. Research in combustion, turbomachinery, fuels, and basic chemistry was included. Like most studies, this study began with a questionnaire. The questionnaire was designed to include five significant topics:

- (1) Self-determination and fulfillment
- (2) Clear goals and objectives
- (3) Management style
- (4) Recognition
- (5) Adequate support

Those who designed the questionnaire felt that these topics, or elements, reflected the major concerns of the division people involved in research. Within each of these categories were a number of relevant subtopics. However, before I discuss these, I would like to discuss the process used to ascertain the feelings of the division personnel about the research environment and possible improvements to it.

After the questionnaire was developed, it was distributed separately to supervisory and nonsupervisory staff. The response to the questionnaire was generally very good; people took time to complete the questionnaire and to give meaningful responses. After the surveys were collected, the principal issues were identified and listed. Then, the results were shared with the supervisory and the nonsupervisory groups; each group was provided only with the results of the input it had given. At this time, the input from one group was not shared with the other group. Recommendations were made by the supervisors and nonsupervisors, respectfully, at their feedback sessions. Later, at a division supervisory meeting, the nonsupervisory recommendations were reported, and supervisors decided on the responses to these. The final step was implementing the action items. It was also decided that feedback should occur with the implementation and that the action, or response to the action, should serve as feedback to the nonsupervisory personnel.

The overall intent of the exercise was to identify both the positive and the negative factors that influenced the division's capability to conduct research. It was hoped for that a plan would be developed to initiate remedial action where deficiencies were apparent, to reinforce existing positive activities, and, finally, to increase the staff involvement in decisions affecting their performance and the division program.

Now let me return to the questionnaire itself and further explain each of the topics addressed in it. Each recipient was asked to render an opinion about several statements in terms of how that particular subject was being handled in the division: whether it was poorly done or well done, and whether or not that topic was important or not important. By use of a two-dimensional grid or box in which the ordinate showed "how the topic was handled" in the division and the abscissa showed "its importance," it was possible to obtain

some very quick determinations of how approximately 100 persons felt about a particular element of the research environment.

The five main topics of the questionnaire and their subtopics are listed as follows:

**(1) Self-Determination and Fulfillment**

- Opportunity to achieve personal goals
- Optimum use of skills and abilities
- Participation in setting goals and choosing work assignments
- Upward mobility
- The dual career ladder
- Training and advanced study
- Availability of discretionary time

**(2) Clear Goals and Objectives**

- Consistent commitment to long-term objectives and priorities
- A clear relationship of basic to applied research
- Balance between basic and applied research
- Communication of the agency or parent organization goals
- How the work of the local unit fits into or supports the overall goals
- The flexibility of goals

**(3) Management Style**

- Reception of new ideas
- Support of basic research
- Minimum time spent on administrative duties
- Trust of management
- Opportunity to interact outside the local group
- Opportunity to interact outside the laboratory
- Attraction of new talent and skills to the organization
- Encouragement of participation in goal setting

**(4) Recognition**

- Financial and special recognition awards
- Reports and oral presentations
- Travel opportunities
- Fair promotional system
- Appropriate position titles for staff
- Opportunities for technical exchanges and public exposure

**(5) Adequate Support**

- Funding of approved programs
- Availability of technical support
- In-house shop facilities
- Office and laboratory space
- Computing and computer services
- Secretarial support
- Engineering support for research operations
- Engineering design support
- Procurement support
- Report review by peers
- Report editing and publication
- Graphics and photographic support
- Library

In the feedback sessions held with the nonsupervisory staff, it was clear that there was considerable concern about **Recognition**. More information about the promotion process in a division was desired, and concern about position titles for nonsupervisory personnel was expressed. Also, there was concern that the dual ladder system was not working as well as it should in the promotion process.

In the second major feedback area, **Goals Communication**, there was concern that more frequent discussion of goals should occur and that meetings to discuss goals should be opened to the staff. Review of the division goals on a regular basis was also recommended.

The third major area of feedback was **Optimum Use of Talent**. Respondents desired a more open atmosphere for exposing problems in the conduct of research and also the acceptance of failure as a risk of doing research. Another recommendation called for more meaningful long-range planning. Still another called for greater opportunity to do exploratory research funded by a discretionary funding source. The feedback on the major topic of support included recommendations that a design group and a technology technician group be included in the division organization. It was also recommended that the support divisions be more accountable for supporting research activity.

Several interesting recommendations, which became action items, resulted from this whole exercise. Among them were recommendations for the development of charter documents to describe the principal mission of each organization within the division; circulation of a monthly bulletin to describe the principal accomplishments of the research and to announce any program reviews prepared for upper management; presentation of the promotion policies and procedures of the division to the staff through special sessions; better organizational integration of researchers and operations-type engineers; provision of job titles in recognition of professional status; and, finally, more involvement of all senior research people in project planning and goal setting.

What did this evaluation exercise do for this research division? First, it enabled the division to see its strengths and weaknesses in an honest forthright manner. Second, the process encouraged the participation of the entire staff, both supervisors and nonsupervisors. Third, it gave the research managers much to ponder, and, fourth, it promoted some remedial action and follow-up, performed to the satisfaction of the staff. I believe that this kind of research operations assessment, or something similar to it, is a mandatory step that any research organization must perform periodically. Although it takes some time, the effort, if properly conducted, can lead to some very positive results.

I have devoted considerable space in this paper to recalling this assessment exercise in a research division. As a participant in the leadership team that conducted this exercise, I thought the exercise was one of the most interesting and rewarding assessment exercises that I had ever been exposed to, and it gave me some new insights into the management of research. In some respects, the whole exercise demonstrated the validity of some of the concepts discussed in management theory courses. In one of these, the Johari Window exposure and feedback are major parameters in the desired profile of good management. The assessment exercise received herein fulfills that principle. In

other paragraphs of this article, I will repeat some of the findings of this research environment survey.

## MANAGEMENT PRACTICE

All managers whether they are high-level executives, midlevel managers, or first-line managers are involved in the following practices:

- (1) Setting goals
- (2) Planning
- (3) Staffing
- (4) Reviewing, measuring, and evaluating
- (5) Recognizing and rewarding

I will comment on each of these practices from the viewpoint of either a first-line or a midlevel manager of research.

The first management function is **Setting Goals**. A middle manager, or first-line manager, is given a set of overall goals for the parent organization. It is the manager's job, at this level of management, to understand clearly what the goals and objectives are for the parent organization. The manager interprets these overall goals in terms of objectives or goals for his or her organization. These organizational goals, then, must be communicated to the staff so that all understand the meaning of the goals and how they relate to the overall goals of the parent organization. Establishing an understanding of the organizational goals and the overall goals of the parent organization is a very important job in the management process.

**Planning** is the second function. The plans that are developed, whether they are short-range or long-range, must be relevant to the goals decided on for the organization and consistent with the long-range goals of the parent organization. There should be a correlating relationship between the two. A good manager identifies promising future areas of research and involves researchers in setting goals. In fact, throughout all of the procedures of management, participation is a key element to the success of a research organization.

The third management function is **Staffing**. In my judgment, the development of the staff or recruiting of staff for research is the highest priority function of the manager. In some cases, the manager will be assigned a staff to carry out a prescribed research function. In other cases, the manager will have the opportunity to recruit the staff that will be used to carry out the research. In either case, a manager has the opportunity to develop the staff to carry out the research assignments. If the manager is recruiting staff, certain characteristics should be sought in the persons under consideration. These characteristics are listed here in a random order of importance.

(1) The person should be inquisitive and should have broad interests in technical matters even if the area to be staffed might be highly focused. A substantial general background in the physical sciences should support these broad interests.

(2) A good researcher should be innovative and highly motivated. A self-starter, he or she, should require little day-to-day supervision.

(3) Research is a risky business. A candidate should be willing to take risks and even to accept failure. In conjunction with that, a person should be receptive to new ideas and able to take criticism.

(4) Finally, and very important in my list, the candidate should be able to communicate ideas both orally and in writing.

The list presented is very demanding, and it is not likely that every (or any) research candidate will possess all these characteristics.

The fourth function of a manager is **Reviewing, Measuring and Evaluating**. These actions should occur simultaneously, and so they are listed as one function. A manager should not perform the reviewing function in isolation. The entire organization can be involved. The manager should convene review sessions where ideas are shared and honest discussion is encouraged among experts from within the organization and from those that can be drawn in from the outside to serve as peer reviewers. While reviewing is going on, the measuring and evaluating functions are also occurring, simultaneously. The research manager must cultivate external communication with researchers in industry, universities, and government laboratories in order to carry on this effective review process.

The fifth function of the manager is in the area of **Recognition and Issuing Rewards for Good Work**. A good manager will take advantage of opportunities to use available awards and recognitions to encourage and inspire the staff to perform. Encouraging staff to engage in further training supported by the organization is one of the key elements in rewarding and recognition. Another way to recognize staff is to encourage participation in technical societies and in technical meetings as reward for outstanding contributions of research.

These five management functions are performed in a cyclical fashion. That is, the process, beginning with setting goals and then, finally, arriving at providing awards and recognition for accomplishments, is a repeated process. While it is going on, the middle or first-line manager informs higher management about the progress and results coming from the research in an understandable, comprehensive fashion. The supervisor must be familiar with the technical aspects of the research so that he or she can effectively communicate and advocate them to upper management. Communication with upper management is a key element in the success of a middle or first-line manager. In some circles, a notion prevails that a manager trained in management principles can manage anything, whether it is a project or research. In basic and applied research, I do not believe that just any manager can effectively guide a research organization in a particular assignment or task. I agree that the manager should know something about management as a topic per se, but I also am certain that manager effectiveness depends on basic knowledge of the technical aspects of the research topic being supervised.

#### PLANNING AND SELECTING RESEARCH

Previously, it was mentioned that the judicious selection of a key technical area is one of the most important functions of a research manager. From my own experience, I can cite one example of a particularly good choice that led to several years of productive research. It also turns out to be an example



of the transfer of a national technical objective down to the working level of a small research group. The larger overall objective was the development of a more energetic rocket propulsion system capable of propelling payloads for space missions under study. The new space agency, NASA, had just been authorized by Congress, and there was a flurry of excitement about future space missions that might be executed. One of the principal parameters in the study was the type of propellant combination that would offer the best possibility for achieving ambitious missions. In this time period, the country had not yet committed itself to the manned moon landing, but planners were looking at such possibilities. The propellant combination of hydrogen and oxygen emerged as the prime candidate for the next generation chemical rockets. Among the major technical problems for such an energetic system was the cooling of the rocket chamber and the nozzle. Either the oxidizer or the fuel would serve as a coolant by circulating one or the other through passages in the rocket engine. Hydrogen appeared to be the best possibility because it had attractive heat capacity. However, little was known about its behavior as a convective coolant. My research section proposed a research program to study the cooling characteristics of liquid hydrogen for anticipated fluid-state conditions in rocket engines.

After taking on the task, I found there were several key challenges in the execution of the program. One of the most challenging was the thermodynamic state of the fluid. Hydrogen has a rather low critical pressure, 12.8 atm, which made it likely that the near-critical state of the fluid would be encountered somewhere in the cooling channel. In the region around the critical point, any fluid has many peculiar property characteristics which make fluid flow and heat transport difficult to predict. Phase boundaries between liquid and gas species become indistinct and disappear close to the critical point. This near-critical region became the focus of much of the experimental study of the heat transfer characteristics of hydrogen. The severe gradients in the physical and transport properties greatly affected the convective cooling characteristics. In fact, the property data were either nonexistent or in question over much of the near-critical regime. The National Bureau of Standards (NBS) was engaged in resolving some of the deficiencies in the property data.

The selection of this research investigation in heat transfer led to a rather broad and lengthy research program. Fortunately, it was a successful program, and the principal investigators received recognition for it. Hydrogen-oxygen was eventually selected as the propellant combination for the upper stages of both manned and unmanned space vehicles. Thus, to those doing the research, it seemed as though their work contributed to a national need. Within the research section, the program led to several interesting ancillary investigations, such as boiling heat transfer studies. Unexpectedly, the boiling studies provided insights into the heat transfer behavior of the near-critical regime.

Perhaps I have digressed here to some extent, but I wanted to emphasize how significant the selection of a research topic can be in the life of a research group. A prime responsibility of the manager is the appropriate selection of such a research topic.

Finally, in the selection of a research topic or focus, it is important to try to select those that are amenable to both experimental and analytical assignments for the staff. In my experience, a balance between these two types

of activities makes for a more unified and comprehensive program, especially if the experimental effort serves the analytical program with verification data. In every research organization, it is not always possible to have both experimental and analytical specialists. If such is the case, then it is advisable to set up communication links between research groups that could complement one another. Perhaps the most ideal situation is to have staff members who are individually active in both areas.

## MANAGEMENT INTANGIBLES

Much of the skill in management involves human relations. Cultivating a meaningful trust relationship with each of the employees on an individual basis is a high-priority item. This does not mean that the manager and staff must become close personal friends in a social sense. It does mean that the supervisor and the employee should establish a relationship of mutual confidence and respect. The employee sees the supervisor or manager as an essential element in carrying out the research program. If that isn't true, then the manager may be viewed as an impediment to the program, certainly not a desirable role for a manager. In a healthy relationship, the employee senses the interest of the manager in him or her as a person and not just in the research program. It is apparent that the manager wants the researcher to succeed and to advance in his or her career.

Ethical practice in performing research is one of the key elements in a productive relationship. There is no room in research for shoddy or shady performance. Research results must represent the truth as best as it can be determined. A cardinal rule in management is to cultivate high ethical standards in performing the work. Ethics also pertains to the nature of the personal conduct between the manager and the employees. The effectiveness of any organization will be adversely affected by improper conduct.

"Management" in research is synonymous with "encouragement" of the same. Encouragement includes actions such as watching for training opportunities that will enable an employee to grow technically and promoting participation in technical sessions and conferences where peer commentary will be available. It involves the day-to-day recognition of achievements when they occur. When an employee senses that the supervisor is extending support and encouragement, further incentive is provided for improved performance. If a supervisor shows that he or she cares about the performance of the researcher and the progress of the work, it does wonders for both.

Failure is a part of the risk mode in research. When it occurs, the manager serves a vital role as a counselor. The researcher needs some assurance that failure is acceptable and some guidance on restoring the research program. Most failures in research are not total failures. Useful and significant information can result from the analysis of the failure, and a researcher must be encouraged to carry out such an assessment.

Successful performance in research calls for creativity on the part of the participants. One of the greatest challenges in research management is the cultivation of a creative environment so that individuals or research teams are encouraged to develop creative attitudes and practices in their work. I know that a "Theory X" autocratic supervisor is a roadblock to creativity. The

management style must be the "Theory Y" style as defined by Douglas McGregor in his book, "The Human Side of Enterprise" (ref. 1). For emphasis, I must repeat: It is the trust relationship characteristic of this management style that is so important in cultivating creativity. The trust evolves from the practice of participative decision making in all aspects of the work. This does not mean that the manager does not make decisions. The manager and staff work together in dialogue as the decision is considered. Often the decision forms from a consensus, but not always. The manager has the responsibility for the final decision.

Creativity is encouraged by a manager who enables multifaceted examination of a topic or problem. Previously, I mentioned the value of peer opinions in evaluating research progress. It is equally important to have this resource when a problem is first being examined. Peers will bring fresh viewpoints which will ultimately contribute to creativity. Creativity is particularly valuable to research in the problem-definition and approach-formulation stages.

Managerial support in providing the resources and facilities is important in cultivating creativity. I remember when the laser-Doppler means of measuring fluid velocities was first introduced as an instrumentation technique. Our research group wanted to become involved, but our resources were limited. By scrounging around in instrument pools and allocating funds over two budget cycles, we were able to build up the first test facility of its kind in the whole laboratory. Managerial support had a major positive effect on the creativity of the principal researcher of the project.

In conclusion, positive intangible relationship factors which connect the manager with the employees are vital to a successful research organization. It is well established that a supervisor cannot motivate an employee. However, a supportive relationship with a supervisor may induce self-motivation, and creativity will also be evident.

## FACILITIES

In experimental research, one of the most difficult, and sometimes the most frustrating, managerial tasks is providing adequate test facilities. This requires long-range planning and anticipation of research needs because long lead times are required for the design, procurement, fabrication, and erection of such equipment; this applies equally well to instrumentation and recording equipment. Experimental apparatus are terribly expensive because they are generally one-of-a-kind articles requiring much handwork and special fabrication. If a need for a certain facility is anticipated well in advance, a manager can begin building up that facility in piecemeal fashion by using budget resources from more than one fiscal year. This is often a very prudent procedure in any case because it allows for preliminary testing and calibration of components in a major facility before the entire system is assembled. Another valuable procedure is to build a cheap prototype or model of the desired facility which allows evaluation of important performance features. Such a procedure often uncovers unforeseen features that would limit the finalized design if modifications were not made. In fact, it sometimes happens that the prototype apparatus serves so well that it eliminates the necessity of obtaining the more elegant apparatus planned; or it might reveal a major flaw in the design that cancels or modifies the plans for that apparatus.

Similar comments apply equally well to computing equipment in support of analytical or numerical modeling research. The lead times required for the procurement of such equipment are long. By the time the equipment is delivered, it is somewhat obsolete. The computer market is so dynamic and so full of options that it is difficult to make prudent selections. An important consideration in the selection process involves whether to use centralized or distributed systems. There is no pat answer to this question because so much depends on the particular application need of the research. However, the tremendous advances in the storage and execution capabilities of individual work stations point to the growing use of distributed systems with connections into networks wherein files can be transferred and interaction with a mainframe is possible. It is very clear that computing equipment is becoming a more important research tool for both analytical and experimental research. The useful output of research information by a research organization will depend largely on how well that organization adapts to the use of the computer in either analytical or experimental research. Thus, one of the great challenges to a manager is the selection and application of computing equipment to the research programs in his or her organization. It is a most critical decision and the manager may or may not have local assistance in making it. Careful study and evaluation are mandatory.

#### DELEGATION

Delegation, one of the most important tools of research management, requires planning and clearly defining assignments that will be given to one of the researchers under supervision. In the delegation process, the manager must transfer authority, which is comparable to responsibility, to the researcher. This transfer conveys the manager's trust to the employee. The assignment of a research project to a researcher gives the recipient a sense of ownership (perhaps, better described as stewardship) of the research assignment. A carefully planned assignment will provide considerable challenge for the recipient, and this unquestionably will lead to that person's development and to innovative, creative research. The delegation of a challenging assignment will be evidence of management support to the employee.

After the delegation of the assignment, it is important that the manager continues to show interest in the project without interfering unduly. It is equally important that the manager does not take over, during the course of the research program. If some difficulties arise and the manager is aware of them, he or she should try all possible options before implementing any drastic measure, such as reassigning the project or taking it away from the researcher, in order to avoid some catastrophe. The manager should work with the researcher and assist him or her to correct a difficulty or a situation. Although the manager must release the program to the research investigator, it is equally important that the manager require a regular reporting scheme. The manager should have some knowledge of the project's general status, without an indepth knowledge of all the details, at all times. A manager should be kept informed because he or she should be prepared to defend a project to upper levels of management, at any time.

A manager should insist that the principal investigator document the progress of the project. This documentation provides a good way of transferring progress information to the manager. In good management practice, opportunities ought to be devised for the principal investigator to report on the

progress of his project before peers. Through these progress reports before peers and through the conferences that the investigator has with his immediate manager, it is possible for that investigator to engage in self-appraisal of the progress of the project. A good manager will encourage those he or she supervises to perform self-appraisals of projects.

It is important for the manager to recognize and reward the principal investigator for significant milestones in the conduct of the research, but the manager must be careful not to "over-recognize" progress that is not worthy of special recognition. Throughout the conduct of the delegated research program, the manager should ensure that the progress is tracking according to plan and fulfilling the objectives for that plan. Deviations from a plan or from some stated objectives are allowed, if they are negotiated in a discussion between the manager and the employee. This process is part of the control aspect of good management practice.

Finally, patience, on the part of the manager, is a key virtue in the delegation process.

### CONCLUSIONS AND SUMMARY

Middle managers of research are involved in the traditional practices of management which include goal setting, planning, staffing, reviewing, evaluating and recognizing. In my opinion, the staffing function is the most important. Selecting staff and cultivating their progress leads to a competent organization which in turn enables challenging research to be accomplished.

I would place the planning function next, in order of importance, behind staffing. In the building and maintenance of a successful program, the manager must take the planning initiative. Once the pump of planning ideas has been primed by the manager, a good staff will keep the planning process going. This will be accomplished through participative interaction within the research group itself and external communication with the relevant research community. I place great importance on participative management in research. In fact, I believe the ability to develop a participative style of operation within the organization is a cardinal attribute of a successful manager. In research, there is no place for the autocratic manager who does not allow subordinates to be involved in the planning and decision-making processes.

A middle manager of research serves as an enabler or facilitator. The creation of an environment that allows a researcher to pursue a topic with proper resources and minimum interference is one of the major responsibilities of a good manager. Sometimes that manager must serve as a buffer that protects the researcher from administrative interference and micromanagement from higher levels of management. If researchers sense first-level management support, it does wonders for their latent creativity capabilities. Fundamentally, management involves personal relationships that cultivate trust and respect, which, in turn, encourage and inspire the best performance in people. The manager must be able to delegate the proper amount of responsibility and authority to those who are carrying out a research task and to allow them to carry on independently. Delegation does not mean that the manager loses track of what is going on in the program; to the contrary, he or she keeps apprised of the progress of the program but without unduly interfering in its execution.

I believe the best middle manager of research is one who is technically competent and knowledgeable in the general area being managed. Management skills are important, but technical familiarity with the research topic is more important.

Meaningful recognition and reward are managerial tools that enhance performance. These features are often neglected or misused by middle managers, but they are powerful means of inspiring highly productive research.

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